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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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JOHN H. GIVENS

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EXAMINER

MALDONADO, JULIO J

ART UNIT

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PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 08/801,812	Applicant(s) GIVENS, JOHN H.	
	Examiner Julio J. Maldonado	Art Unit 2823	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 14 May 2007.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-6,9-15 and 64 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-6, 9-15 and 64 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08)
Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

1. The rejection of claim 1 under 35 U.S.C. 112, first paragraph is withdrawn in further view of the claim and the disclosed in the specification.
2. Claims 1-6, 9-15 and 64 are pending in the application.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

4. Claims 1-6, 9-15 and 64 are rejected under 35 U.S.C. 103(a) as being unpatentable over Xu et al. (U.S. 5,847,461, hereinafter Xu '461) in view of Xu et al. (U.S. 6,217,721, hereinafter Xu '721) and Yim (U.S. 5,869,395).

Xu '461 (Figs.1-4) in a related method to form an interconnect teaches forming a recess (14) within a dielectric material (10) situated on a semiconductor substrate (2), wherein said recess (14) extends below a top surface (12) of said dielectric material (10); forming a diffusion barrier layer (20) comprising titanium nitride conformally on the top surface of the dielectric material (10) and over an interior surface of the recess (14); forming an electrically conductive layer (30) comprising aluminum on the barrier layer (20) and covering the top surface of the dielectric material (10), wherein the diffusion barrier layer (20) has a melting point greater than that of the electrically conductive layer (30); forming an energy absorbing layer (40) on said electrically conductive layer (30), wherein said energy absorbing layer (40) has a greater thermal absorption capacity

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than that of said electrically conductive layer (30) and wherein said energy absorbing layer (40) is selected from the group consisting of titanium, tungsten, silicon dioxide and tantalum; using a furnace to apply energy omnidirectionally to said energy absorbing layer (40) causing said electrically conductive layer (30) to flow within said recess (14); and patterning said interconnect (column 3, line 12 – column 7, line 45).

Xu '461 fails to disclose the steps of heating the diffusion barrier layer in an environment substantially containing nitrogen gas; forming a seed layer comprising titanium nitride on the diffusion barrier layer and over the dielectric material, wherein the diffusion barrier layer has a melting point greater than or equal to the seed layer; forming an electrically conductive layer on the seed layer including the portion of the seed layer within said recess, wherein the seed layer has a melting point greater than or equal to that of the electrically conductive layer.

However, Xu '721 (Fig.8) in a related method to form an interconnect teaches the steps of heating a diffusion barrier layer (162) in an environment substantially containing nitrogen gas; forming a seed layer (164) made of a graded titanium nitride, wherein said graded nitride starts as titanium nitride and ends as relatively pure titanium and is formed on a diffusion barrier layer (162) and over a dielectric material layer (142), wherein the diffusion barrier layer (162) has a melting point greater than or equal to that of the seed layer (164); and forming an electrically conductive layer (156) on the seed layer (164) including the portion of the seed layer (164) within a recess (152), wherein the seed layer (164) has a melting point greater than or equal to that of the electrically conductive layer (156) (column 3, line 65 – column 6, line 45).

Although Xu '461 teaches adverse effects that could happen by using a tungsten seed layer (Xu '461, column 1, line 63 – column 2, line 27), Xu '461 is silent on the use of other seed layers and thus is open to use the titanium nitride layer disclosed by Xu '721.

Also since said seed layer in Xu'721 is a composite of titanium nitride and titanium, it would have been obvious to one of ordinary skill in the art at the time the invention was made to substitute titanium nitride layer 20 of Xu'461 with titanium nitride/titanium layer 164 of Xu'721, and use the titanium nitride part as a barrier layer and the titanium part as a seed layer, to arrive at the claimed invention. Furthermore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to form a seed layer after the formation of the barrier layer and prior to the formation of the conductive layer, and having the thermal properties as taught by Xu '721 in the interconnect formation method of Xu '461, since heating the barrier layer in a nitrogen environment substantially reduces the electronic barrier at the metal-semiconductor interface (Xu '721, column 9, lines 39-45) and the addition of titanium nitride as a seed layer improves the flow of aluminum into an interconnect at moderate temperatures (Xu '721, column 6, lines 40-45).

Xu '461 in combination with Xu '721 substantially teach all aspects of the invention but fail to disclose that the diffusion barrier layer and the seed layer are deposited on the recess by a chemical vapor deposition process; that a chemical-mechanical polishing is used to remove portions of the energy absorbing layer and the electrically conductive layer; that the recess has an aspect ratio greater than about four

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to one; and that the recess comprises a contact hole situated below a trench, wherein said semiconductor substrate has a lower substrate and terminates at an opposite end thereof at said trench, and wherein said trench extends from said opposite end of said contact hole to a top surface of said dielectric material and parallel to the plane of the lower substrate.

However, Yim (Figs.2A-2K) in a related method to form an interconnect structure teaches the steps of depositing titanium nitride by a chemical vapor deposition process; using chemical-mechanical polishing to remove portions overlaying a damascene trench formed on a dielectric layer (210); providing a recess comprising a contact hole (260) situated below a trench (240); providing a semiconductor substrate (200) having a lower substrate (202) and terminating at an opposite end thereof at said trench (240), wherein said trench (240) extends from said opposite end of said contact hole (260) to a top surface of said dielectric material (210), and parallel to the plane of the lower substrate (202) (column 4, line 26 – column 7, line 31). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to deposit titanium nitride by chemical vapor deposition, using chemical mechanical polish to remove portions of conductive material overlying the dielectric layer and forming a recess comprising a trench and a contact hole as taught by Yim in the interconnect method of Xu '461 and Xu '721, since this would result in a damascene opening with an alignment tolerance, reduced processing time and a flat topography (Yim, column 3, line 49 – column 4, line 5).

Still, the combination of Xu '461 Xu '721 and Yim fail to disclose that the recess has an aspect ratio greater than about four to one. However, one of ordinary skill in the art at the time the invention was made would have been led to the claimed invention through routine experimentation to achieve desired device dimensions and therefore desired device density and desired device characteristics on the finished wafer. Also, it would have been an obvious matter of design choice bounded by well known manufacturing constraints and ascertainable by routine experimentation and optimization to choose these particular dimensions because applicant has not disclosed that the dimensions are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical, and it appears prima facie that the process would possess utility using another dimension. Indeed, it has been held that mere dimensional limitations are prima facie obvious absent a disclosure that the limitations are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical. See, for example, *In re Rose*, 220 F.2d 459, 105 USPQ 237 (CCPA 1955); *In re Rinehart*, 531 F.2d 1048, 189 USPQ 143 (CCPA 1976); *Gardner v. TEC Systems, Inc.*, 725 F.2d 1338, 220 USPQ 777 (Fed. Cir. 1984), cert. denied, 469 U.S. 830, 225 USPQ 232 (1984); *In re Dailey*, 357 F.2d 669, 149 USPQ 47 (CCPA 1966).

Response to Arguments

5. Applicant's arguments filed 05/14/2007 have been fully considered but they are not persuasive.

Applicants argue, "...Xu '461 teaches that seed layers are undesirable when filling small openings and is directed toward other methods of filling the contact

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openings. (*Id.*, col. 1, line 56 - col. 2, line 27). The Examiner acknowledges that Xu '461 fails to teach or suggest a seed layer. (Office Action mailed March 20, 2006, page 7).

While Xu '461 focuses on the limitations of tungsten as a seed layer, its teaching that that seed layers add "further deposition and planarization steps, resulting in more cost, and less reliability" would apply to seed layers generally. (*Id.*, col. 2, lines 7-9). Thus, Xu '461 proposes a method to "fill very small diameter openings in an insulating layer with metal such [as] aluminum initially deposited on the surface of the insulating layer." (*Id.*, col. 2, lines 19-22, emphasis added)..."

In response to this argument, column 1, line 56 – column 2, line 27 of Xu'461 teaches adverse effects of using tungsten as a seed layers, not of applying seed layers generally, as argued by the applicants.

Also, the applicants need to consider the rejection as a whole. Xu'461 teaches a method of forming interconnect structures including forming a contact opening within a dielectric layer, wherein the contact opening has a diameter of less than 0.5 microns (column 3, lines 36 – 44). Furthermore, Xu'461 teaches forming a barrier layer made of titanium nitride having a thickness of about 150Å to about 300Å (column 3, lines 1 – 15). As the applicants asserted, Xu'461 fails to disclose forming a seed layer.

However, and as stated in the rejection hereinabove, Xu'721 (Fig.8) in a related method to form an interconnect teaches the steps of heating a diffusion barrier layer (162) in an environment substantially containing nitrogen gas; forming a seed layer (164) made of a graded titanium nitride, wherein said graded nitride starts as titanium nitride and ends as relatively pure titanium and is formed on a diffusion barrier layer

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(164) and over a dielectric material layer (142) (Xu'721, column 3, line 65 – column 6, line 45). The combination of layers 162 and 164 comprise a stack 150, and said stack has a thickness of about 50Å to 1,000Å (Xu'721, column 13, lines 7 – 13).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to form a seed layer after the formation of the barrier layer and prior to the formation of the conductive layer having the thermal properties as taught by Xu '721 and a thickness that overlaps the barrier layer of the process of Xu '461, since heating the barrier layer in a nitrogen environment substantially reduces the electronic barrier at the metal-semiconductor interface (Xu '721, column 9, lines 39-45) and the addition of titanium nitride as a seed layer improves the flow of aluminum into an interconnect at moderate temperatures (Xu '721, column 6, lines 40-45).

Also, applicants argue, "...The cited references do not teach or suggest all of the limitations of claim 1 because they do not teach or suggest "forming a seed layer on the diffusion barrier layer over the top surface of the dielectric material and within the recess...". In response to this argument, Xu'461 teaches forming a metal layer 30 over the barrier layer 20, wherein said metal layer 30 covers the openings 14, 16 and accordingly the barrier layer 20 formed over the openings, and wherein a portion of said metal layer is formed within the openings 14, 16 (Xu'461, column 4, lines 16 – 28). Therefore, Xu'461 teaches upon the claimed limitation.

Conclusion

6. Applicants are encouraged, where appropriate, to check Patent Application Information Retrieval (PAIR) (<http://portal.uspto.gov/external/portal/pair>) which provides

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applicants direct secure access to their own patent application status information, as well as to general patent information publicly available.

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to examiner Julio J. Maldonado whose telephone number is (571) 272-1864. The examiner can normally be reached on Monday through Friday.

8. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Matthew Smith, can be reached on (571) 272-1907. The fax number for this group is 571-273-8300. Updates can be found at <http://www.uspto.gov/web/info/2800.htm>.

Julio J. Maldonado
Patent Examiner
Art Unit 2823

Julio J. Maldonado
July 12, 2007


George Fourson
Primary Examiner